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Mechanical Properties and Reliability of Semi-Crystalline Polymers

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The major effort of this project has been the study of the physical and mechanical properties of crystalline polymers and the changes that take place over long-time periods. The study of the long-time crystallization, at ambient temperature, of a series of linear and branched polyethylenes showed a slow but steady density increase with time that could be demonstrated to be due to a decrease in the content of the liquid-like region and an increase in the partially ordered interfacial region. Significantly, the core-crystallinity level remains unaffected by the long time density increase.

A detailed study of the overall crystallization kinetics of a set of model random copolymers, the hydrogenated polybutadienes, that covered a wide range in molecular weight and counit content was competed. A basic understanding of the crystallization process in random copolymers, and of the structural factors which control long-time crystallization from the melt was developed. For the first time it was possible to separate the influence of molecular weight and co-unit content as independent variables that govern crystallization.

A micro-tensile apparatus that enabled eight to ten repetitive measurements to be made, using only 150 mg. of sample, was designed and constructed. This advance in instrumentation enabled molecular weight fractions and narrow composition copolymers to be studied. The brittle-ductile transition in linear polyethylene was studied and reported in detail. The transition in deformation type was found to be very sharp with crystallinity level. The molecular weights and crystallinity levels that demarcate the deformation were established. Key tensile properties, such as yield stress, draw ratio at break and ultimate tensile stress were

studied as a function of molecular weight, crystallinity level and morphology utilizing fractions of linear polyethylene. A publication describing this work is in preparation.

We have also studied the fusion and crystallization kinetics of molecular weight fractions of poly(vinylidene fluoride). Particular emphasis was given to the influence of the head-to-head structures, typical of this polymer, on the melting temperature and crystallization rate for a constant molecular weight.

Publications:

1. R. G. Alamo, K. W. McLauglin and L. Mandelkern, "Changes in the Phase Structure of the Polyethylenes After Long-time Storage at Room Temperature," *Polym. Bull.*, **22**, 299-306 (1989)
2. A. K. Nandi and L. Mandelkern "The Influence of Chain Structure on the Equilibrium Melting Temperature of Poly(vinylidene fluoride)," *J. Poly. Sci.*:Part B Vol.29, 1287 (1991).
3. R. G. Alamo and L. Mandelkern, "Crystallization Kinetics of Random Ethylene Copolymers," *Macromolecules*, **24**, 6480-6493 (1991).
4. L. Mandelkern, F.L. Smith, M. Failla, M.A. Kennedy and A.J. Peacock, "The Brittle Ductile Transition in Linear Polyethylene," *J. Polym. Sci., Polym. Phys. Ed.*, **31**, 491-493 (1993).

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